CHAPTER 2: HEALTHY SOIL

"Humans... are truly a product of the soil and reflect in their bodies—and minds—the wealth or poverty of this land."

Dr. Helmut Kohnke, "Soil Science Simplified"

In this chapter, you'll find information about:

- Soil and human civilizations
- Benefits of healthy soil: overview of soil functions
- Basic soil science, the all-in-one resource: Home Gardener's Guide to Soils and Fertilizers by Craig Cogger, Extension Soil Scientist, Washington State University
- Soil organic matter
- The soil food web
- How soil is formed: aka the five factors of soil formation
- Outreach materials

"...soil is humanity's most essential natural resource and essentially linked to modern civilization's survival."
David Montgomery

Soil and Human Civilization

Whole books have been written about the connection between soil fertility and the success or failure of human civilizations cultivating the land. One such book is *Dirt: The Erosion of Civilizations*, by David Montgomery. As one reviewer described, Montgomery argues persuasively that soil is humanity's most essential natural resource and essentially linked to modern civilization's survival. He traces the history of agriculture, showing that when humans exhausted the soil in the past, their societies collapsed, or they moved on.

As compost educators, the importance of caring for the soil is a vital part of the sustainability message. Soil and the history of civilization may be one of the topics you choose to include in your curriculum. The reference books in the Resources section will provide several examples to share with your audience.

Benefits of Healthy Soil: Overview of Soil Functions

Soil has many functions in the world. For composters and gardeners, probably the most important function of soil is to grow plants. From a broader perspective, healthy soil gives us clean air and water, bountiful crops and forests, productive rangeland, diverse wildlife, and beautiful landscapes. Soil does all this by performing five essential functions:

- *Nutrient cycling:* Soil stores, moderates the release of, and cycles nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant available forms, held in the soil, or even lost to air or water.

In a vintage '70s book on soils for gardeners, Gene Logsdon—long-time farm and garden writer—introduces a sport we may want to revive for the 21st century biological era: soil watching. Probably you already engage in this sport, in the privacy of your own thoughts. Now you can put a name to the activity and share the wonder of Washington soils with fellow educators in the network. And what better state than Washington, with its varied topography and climate, to revive soil watching as the best travel game going?

Soil watching—as the name implies—is a fairly straightforward activity. Along your chosen route, you observe roadside cuts, gardens, plants, forests, etc. and talk about soil health based on these varied observations. It is more than just roadside geology, though you may want to take along a copy of *Roadside Geology of Washington* to enhance your experience. Think of how much more you'll get out of meetings when you travel with an eye on soils! Caution: Carpool drivers should (obviously) forfeit the watching part of soil watching and keep their eyes on the road. Enjoy the conversation and share piloting duties so all get a chance to view the roadside beauty of soils.

- ***Water relations:*** Soil can regulate the drainage, flow and storage of water and solutes, which includes nitrogen, phosphorus, pesticides, and other nutrients and compounds dissolved in the water. With proper functioning, soil partitions water for groundwater recharge and for use by plants and soil animals.

- ***Biodiversity and habitat:*** Soil supports the growth of a variety of plants, animals, and soil microorganisms, usually by providing a diverse physical, chemical, and biological habitat.

- ***Filtering and buffering:*** Soil acts as a filter to protect the quality of water, air, and other resources. Toxic compounds or excess nutrients can be degraded or otherwise made unavailable to plants and animals.

- ***Physical stability and support:*** Soil has the ability to maintain its porous structure to allow passage of air and water, withstand erosive forces, and provide a medium for plant roots. Soils also provide anchoring support for human structures and protect archeological treasures.

Many soil scientists have other lists of soil functions. They can be found on the *soilquality.org* website under *Alternative Soil Functions*.

Basic Soil Science

This section contains an all-in-one resource about soils and fertilizers, WSU Extension Bulletin 1971e: *Home Gardener's Guide to Soils and Fertilizers* by Craig Cogger. The document is suitable and available as an Extension Bulletin for outreach and is included in this *Compost Educator's Guide* for your use in trainings. If you need more in-depth information, please refer to the resources for a list of soil science books.

Soil Organic Matter

Soil organic matter is often viewed as the thread that links the biological, chemical and physical properties of a soil. Though it typically amounts to only <1 to 5 percent of soils, organic matter has a big impact on soil health.

Here is a list of the ways in which organic matter affects soil quality:

1 Stores and supplies plant nutrients Nitrogen, Phosphorus, and Potassium (N, P, and K) and micronutrients; increases cation exchange capacity.

2 Stabilizes and holds soil particles together as aggregates.

3 Helps soil to resist compaction, promotes water infiltration, and reduces run-off.

4 Aids growth of crops by improving the soil's ability to store and transmit air and water, as measured by improved porosity; water holding capacity, and drought resistance.

5 Makes soil more friable and easier to work so that plant roots can penetrate the soil profile better.

6 Provides a source of carbon and energy for soil microbes which cycle nutrients and fight plant diseases.

7 Reduces the negative environmental effects of pesticides and other pollutants by binding contaminants.

The Soil Food Web

Soil organic matter is integrally tied to the soil food web. Soil biology was not widely promoted in education programs until the 1990s. Soil biology became more visible in education programs when the USDA published a popular document called *Soil Biology Primer*. The document provides a wonderful overview of life in the soil, with photographs and descriptions of each category of creatures that make up the complex food web of the soil.

The soil organisms interact with one another in a complex web, converting nutrients and energy as predator or prey depending on their feeding level. The organisms can be grouped generally into the following categories:

- Bacteria
- Fungi
- Protozoa
- Nematodes
- Soil anthropods
- Earthworms

Depending on the ecosystem, soil organisms concentrate where they can find food:

- Around roots
- In litter
- On humus

- On the surface of soil aggregates
- In spaces between soil aggregates

In summary, the *Soil Biology Primer* offers this overview of the importance of soil biology:

How the Soil Food Web Functions to Benefit the Gardener

- Fertilizer requirements may decline as a healthy food web efficiently stores and cycles nutrients.
- Nitrates do not leach into groundwater when soil organisms hold nitrogen in the rooting zone.
- Water quality is protected when organisms effectively degrade pollutants.
- More water soaks into soil, and can be used by crops as biological activity enhances soil structure.
- Less topsoil is lost to water and wind erosion where soil organisms have stabilized the soil structure.
- Pesticide use can be reduced as disease suppression improves with a healthy soil food web.

How Soil is Formed: The Five Factors of Soil Formation

Hans Jenny (1899–1992), soil scientist from the University of California, Berkley, experienced notoriety when his book, *The Factors of Soil Formation*, was published in 1941. In his book, Jenny made the connection between observations of soils in their natural state, and mathematical equations describing the forces that made them. The book is still considered one of the most important contributions to soil science, and was re-published with a new foreword in 1994, two years after Jenny died.

The five factors of soil formation are:

- Topography (or relief)
- Parent materials
- Climate
- Biota
- Time

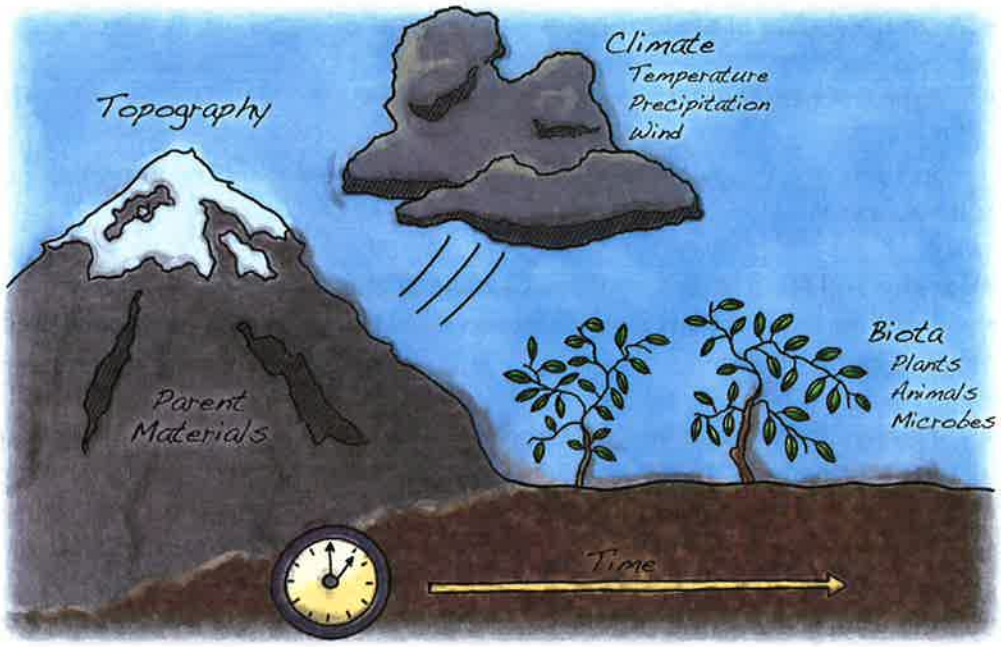

Figure 2.1. Here is an easy way to remember the five factors of soil formation.

Soil formation is a fascinating study. It adds a perspective of geologic time to a composting/yard care education program. And it may help people to relate to the nature of soils in their own yards.

Outreach Materials

For information on soils and fertilizers, the following two documents are available to distribute at outreach events:

EB 1971e. Home Gardener's Guide to Soils and Fertilizers by Craig Cogger, WSU Soil Scientist.

EC 1561. Improving Garden Soils with Organic Matter by N. Bell, D.M. Sullivan, L.J. Brewer and J. Hart, Oregon State University.

Resources

Books

Dunne, Niall (ed). 2009. Healthy Soil for Sustainable Gardens. Brooklyn Botanic Garden.

Gershuny, Grace. 1993. Start with the Soil, Emmaus, PA: Rodale Press.

Hillel, Daniel. 1990. Out of the Earth: Civilization and Life of the Soil. University of California Press.

Howard, Sir Albert. 2006. The Soil and Health. Lexington, KY: University Press of Kentucky.

Jenny, Hans. 1994 Factors of Soil Formation: A System of Quantitative Pedology. Courier Dover Publications.

Kohnke, Helmut, and D.P. Franzmeier. 1995. Soil Science Simplified, 4th edition, Long Grove, IL: Waveland Press, Inc.

Magdoff, Fred, and Harold van Es. 2000. Building Soils for Better Crops, 2nd edition. Beltsville, MD: Sustainable Agriculture Network.

Smillie, Joe, and Grace Gershuny. 1999. The Soul of Soil, 4th edition. White River Junction, VT: Chelsea Green Publishing Company.

Other publications

2000. Soil Biology Primer. Ankeny, IA: Soil and Water Conservation Society.

www.swcs.org; pubs@swcs.org; or (800) THE-SOIL extension 24 or 7515.

Cooperband, Leslie. 2002. Building Soil Organic Matter with Organic Amendments – A resource for rural gardeners, small farmers, turfgrass managers and large-scale producers, University of Wisconsin, Madison.

http://www.cias.wisc.edu/crops-and-livestock/building-soil-organic-matter-with-organic-amendments/

Soil Science Society of America. Soil Science Glossary. 2008

https://www.soils.org/sssagloss/pdf/soil-science-glossary.pdf

Soils and civilization

Soil Quality Website. http://soilquality.org/home.html

The Soil Quality website has a list of books on soils and civilization. Here is a description of the most recent publication listed:

Dirt: The Erosion of Civilizations. 2007. David R. Montgomery. University of California Press. Dirt, soil, call it what you want—it's everywhere we go. It is the root of our existence, supporting our feet, our farms, our cities. This fascinating yet disquieting book finds, however, that we are running out of dirt, and it's no laughing matter. An engaging website on the natural and cultural history of soil that sweeps from ancient civilizations to modern times. *Dirt: The Erosion of Civilizations* explores the compelling idea that we are—and have long been—using up Earth's soil.

Soil testing

The Washington State University Website Soil Testing has several references including a Power Point slide presentation on testing soils and the two documents listed below the URL. The site also includes a list of laboratories where you can send soil samples. http://www.puyallup.wsu.edu/soilmgmt/SoilTesting.htm

Gardner, E.H. and J. Hart. 1995. Soil sampling for home gardens and small acreages. Oregon St. University. Extension Service. EC 628. http://extension.oregonstate.edu/catalog/pdf/ec/ec628.pdf

Marx, E.S., J. Hart, and R.G. Stevens. 1998. Soil test interpretation guide. Oregon St. University. Extension Service. EC 1478. http://extension.oregonstate.edu/catalog/pdf/ec/ec1478.pdf

Other Washington State University soils links

The URL listed below has a Power Point slide of soils in the Puget Sound area. It also links to several USDA sites that provide a wealth of information on soil types, classifications, maps, soil quality, state soils, soil uses, etc. http://www.puyallup.wsu.edu/soilmgmt/Soils.htm

Other soil links: Activities to inspire soil stewardship

The Soil-net website has lots of fun activities to download and use in the soils part of your curriculum. http://www.soil-net.com/

Soils.org is a website associated with the Soil Science Society of America. It has good links to other websites with soils activities. It also has a pdf file of the well-known apple demonstration to show how much soil on the earth is capable of supporting agriculture. https://www.soils.org/lessons/plans/

References

Kohnke, Helmut, and D.P. Franzmeier. 1995. Soil Science Simplified. Long Grove, IL: Waveland Press, Inc.

Montgomery, David. 2007. Dirt: The Erosion of Civilizations. San Francisco: University of California Press.

National Soil Quality Team. 2008. University of Illinois; Iowa State University; USDA Agricultural Research Service, National Soil Tilth Laboratory; USDA Natural Resource Conservation Service. http://soilquality.org/home.html